Fig. 14.—Ganglionic bodies with their net-work from the cerebrum of Amphiuma tridactylum. Magnified 420 diameters.

Fig. 15.—Ganglionic bodies from one of the abdominal ganglia of *Blatta orientalis* (cockroach), showing their mutual connection by means of anastomosing nervous filaments.

Fig. 16.—The same, after the action of acetic acid.

Art. II.—CONTRIBUTIONS TO ENCEPHALIC ANATOMY.

By Edward C. Spitzka, M. D., of New York.

PART V.

The Organology of the Island of Reil.

IN previous pages of this series I have adverted to the fact that an anatomical identity or similarity existing between the corresponding areas of two given brains, does not imply that those areas are also functionally homologous. The less likely is an anatomical similarity to involve a physiological similarity, the nearer we approach the highest centres ; while an atrophy (I am speaking of the *normal* atrophies in the zoological series) or over-development of the central tubular grey matter and the nerve roots, can be readily referred to corresponding defects or higher developments of the related periphery, and comparative physiological deductions can be derived from this relation ; the cerebral and cerebellar cortical areas do not admit of such being made. I consider the establishment of this fact so important in its bearing on the question of cerebral localizations, and especially on those which are grounded on localized irritations of the cortex in the lower animals, that I have made an extensive series of dissections of that cortical territory which can be most readily identified in the amniote animals, namely, the island of Reil, in order to illustrate the principle involved.

Various views have been advanced by morphologists and embryologists as to the cause of the cortical retraction, which results in the more or less complete isolation of the island.

Some of these are fanciful, and I shall not refer to them in detail. I find that those animals which in the adult condition exhibit a rudimentary *fovea* corresponding to the *fossa Sylvii*, while in their embryonic state undergo a marked prosencephalic incurvation. No animal possesses this fossa, unless it undergoes this incurvation ; for this reason, and for others to be detailed, I regard the primary cause of the development of the fossa to lie in the same traction which determines the prosencephalic curve. This traction is exercised by that portion of the *hypoblast* which furnishes the future pharynx, and which in the early embryo is adherent to the base of the grey matter surrounding the third ventricle. The resulting tension is transmitted to that part of the hemisphere which is most intimately connected with the point where the hypoblast is adherent, and it thence results that only a basi-lateral part of the thin-walled hemispheric vesicle is drawn in. Even the brain of the adult human being exhibits a direct continuity of the lower apex of the island with the grey, perforated lamina, which is continuous with the basilar grey matter of the third ventricle, in other words, with the infundibulum of the pituitary body. We know that the latter is a process dragged out of the base of the brain when the traction of the hypoblast reaches its maximum. At the floor of the ventricle, corresponding to the furrow of traction, there must exist a corresponding projection inwards, and this projection is the starting-point for the development of the corpus striatum.

We thus perceive that the traction* exercised by the hypoblast upon the central nervous system produced, firstly, the prosencephalic curve ; secondly, the fovea of the Sylvian fossa, and through the latter, the corpus striatum ; finally, the hypophysis cerebri (pituitary body). Those observers who, like His, refer the island of Reil to the checked expansion of that cortical area which, from its vicinity to the corpus striatum, becomes fused with it, have reversed the true relation of cause and effect ; it is not the position of the corpus striatum which determines the formation of the Sylvian fossa, but the latter

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*Due, in its turn, to the discrepancy of growth between nervous blastema and hypoblast, greater in higher than in lower animals, and absolutely *nil* in amphioxus.

which determines the former. If it were as His claims, then the outline of the fossa, respectively the island, would correspond to, and be determined by the corpus striatum, and the deepest part of the fossa would correspond to the thickest part of the latter ganglion; but this is not so; the island in lower animals does not follow the outline of the latter, and as to the second point, it is controverted by the brain of the turtle, which has a shallow Sylvian fovea whose deepest part corresponds to a depression of the corpus striatum. It is true, however, that all animals that possess a true corpus striatum, also have a Sylvian depression, and that those having the latter, also possess the former, but this is explained equally by the representation made above, as by the hypothesis of His.

Since there is a great deal of ambiguity in the use of the terms fissure of Sylvius, island of Reil, and fossa Sylvii, I shall venture to suggest a uniform, and I trust, applicable nomenclature. It is obvious that the shallow groove of a turtle's or a serpent's brain, although homologous with the island of Reil, hardly deserves the term " island," nor even that of a fossa. I propose to call such depression of the cortex " fovea centralis." Such a fovea is present in all the true reptiles and in birds. A higher degree of development is manifested where a more or less sharply defined area is drawn in, lying at a deeper level than the surrounding cortex; let us term this "fossa centralis;" such a one is present in the rodentia, insectivora and some marsupials. A still higher stage is that in which the surrounding convolutions more or less completely overlap the retracted area; since the latter, therefore, becomes a specialized cerebral division, and in its rotundity and bulk approaches other demarcated cortical provinces, it now merits the appellation " lobus centralis."[*] It is found in the carnivora, both terrestrial and aquatic, the solipedes, herbivores, elephant, hippopotamus, old and new world monkeys, and in man. In this series it presents varying degrees of concealment beneath the overlapping margins of contiguous lobes; it therefore admits of further classification into the " concealed " and the " exposed " lobus centralis. It is completely, or almost completely concealed in *man*, the troglodyte apes, the

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[*] Ecker.

baboon, Cercopithecus macacus, Lagothrix, Cebus and Ateles, also the seal, possibly in the porpoise and very probably in other simian forms not examined by myself.

In none of the anamniote animals have I been able to detect anything that could be fairly interpreted as even a " fovea centralis." I was consequently much surprised to find that Meynert, in a recent publication* refers to a specimen of a *fish's* brain, demonstrated to him by my teacher, Professor Shenk, which he claims proved the universal dependency of the island of Reil on the development of the corpus striatum. This was a lamentable misconception, for, in the first place, neither the bony nor the cartilaginous fish possess true lateral ventricles ; they have no corpus striatum, nor do they either in the embryonic or mature condition exhibit anything even remotely allied to the Sylvian fossa. In the rest of his monograph, Meynert very properly insists that the fissure of Sylvius should be considered the starting-point for the nomenclature of the gyri, but in the instance alluded to his desire to establish a wide-spread homology has led him into an error ; there is a limit beyond which it would be fruitless to attempt homologizing here.

The " lobus centralis " of the higher mammalia follows no definite law visible on first sight, as regards its dimensions or relations. If we were to assert that it was largest in the highest animals, we should be in error, for this lobe is larger in the hippopotamus than in the seal ; if we were to determine the position intellectually of an animal by the number of gyri on this lobe, we should be forced to the ridiculous conclusion that the hippopotamus rivaled the human being and far exceeded the anthropoid apes. In like manner, would it be erroneous to state that the more completely the island of Reil (lobus centralis) was covered by surrounding cerebral parts the higher its own development. In the seal, although entirely covered, it is rudimentary; in the human being, in which it is also covered, and in the hippopotamus, in which it is practically uncovered, on the other hand, it is very large. Even

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* "Die Windungen der convexen Oberflaeche des Vorderhirnes bei Menschen, Affen und Raubthieren," von Prof. Theodore Meynert. *Arch. fuer Psychiatrie*, VII.

where in allied groups, the island is entirely covered, the dimensions, as well as the convolutions of the latter, may vary greatly, as instanced in the anthropoid and lower apes compared with man.

We thus see that no constant relation exists between the degree of development of the lobus centralis and that of the remainder of the cortex, from which it follows that it is no indication of cerebral development in general.

It now remains for us to see whether there is any constant agreement between the island and the fibre masses, or ganglia, at the base of the brain. In regard to this question it is unfortunate that we have not a sufficient number of observations at our disposal. I especially feel the absence of such dissection in the case of the seal* and hippopotamus.† I limit myself, therefore, to the rodentia, terrestrial carnivora, cheiroptera, and the simians, including man ; in this series, I find a relative agreement between the outline and dimensions of the island of Reil and the nucleus lenticularis of the corpus striatum.

Since the island and the bordering areas send their fibres into this ganglion, the cause of this dependency is clear. According to Meynert, the efferent fibres of a large portion of the nucleus lenticularis run inwards, as the fourth stratum of the ansa peduncularis, to become the most internal fibres of the pes pedunculi ; these same fibres are supposed on very strong grounds to place the cranial nerve nuclei under the control of the higher centres. We judge the latter from the course of the raphe fibres, and the greater thickness of the raphe in those regions where the hypoglossal, facial and motor trigeminal nuclei are situated. I can attribute no value to the contradictions of Flechsig,‡ who, misled by his exclusive study of a single method, maintains that the entire mass of the pyramidal fibres contained in the pes pedunculi terminates in the præ- and post-central gyri ! A large portion terminates thus undoubtedly, but not the whole. In the light of Mey-

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*The only specimen of the former in my possession decayed in the preserving fluid.

†Examination not concluded at date.

‡"Weitere Beobachtungen ueber den Faserverlauf innerhalb der nervoesen Centralorgane." *Centralblatt,* No. 3, 1877.

nert's description, there would exist a communication between
the cortex of the island and the cranial nerve nuclei. We
would except from this the nuclei of the oculo-motor, trochlearis
and abducens nerves, in whose case other relations can be
established, while no raphe fibres can be traced to them.   This
connection finds a strong support in pathological experience,
and receives confirmatory support from comparative anatomy.
The seal, whose facial muscles are rudimentary and whose
tongue is not freely movable, has the most reduced island of
Reil in the mammalian series, and as the sequel will show, it is
doubtful whether its insula is strictly homologous with that of
other mammals.

I shall now proceed to describe the lobus centralis in a series
of higher mammals in order to illustrate the propositions
advanced, and to determine the much-vexed question of the
localization of speech.

In the land carnivores, such as the cat, lion, and dog, the
lobus centralis runs anteriorly into the orbital surface of the
frontal lobe without any boundary, only a small triangular part
of the island is covered, and this is perfectly smooth, present-
ing not even the faintest traces of sulci or gyri, the nucleus
lenticularis, which in these animals is very small compared
with the corpus striatum, corresponds pretty accurately in its
outline with the covered part of the lobus.   The bear, whose
brain in all respects far exceeds in development that of other
land carnivores,* presents a marked advance in these respects;
not only is his insula larger, but it actually possesses a single
sulcus running in an antero-posterior direction and dividing
it into two gyri.   Its anterior border is externally as vaguely
defined as in the lion or dog, but the lenticular nucleus is
larger proportionately, and extends further forwards than in
these animals.   As the bear's brain presents a marked advance
on the other carnivora, both in the general character of the
brain and the development of the special territory in question,
the seal exhibits a still greater development of the brain in

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*As shown in the size and convolution of the hemispheres, the posterior
inflection upwards of the gyrus fornicatus, the high development of the
frontal and temporal lobes, the prominence of the olivary bodies, and the
almost complete concealment of the trapezium.

general, but a remarkable retrogression of the lobus centralis. If after identifying the deep and diagonally running fissure of Sylvius from among the numerous meandering sulci of the seal's cerebrum, we separate its walls, we shall, after tracing the fissure to a greater depth than even in the human brain, be surprised to find but a narrow area, measuring in diameter not quite three-quarters of an inch, representing the lobus centralis. This area, however, is not overhung as in other placental mammals by the parts analogous to the operculum, and posteriorly and upwards the area representing the lobus centralis, after dividing into two gyri, runs out of the fissure of Sylvius to gain the free surface of the convexity. Its two sulci run backwards and inwards on either side of that fissure which corresponds to the fissure of Rolando.

At the base of the hemisphere, the apex to which this area dwindles is continuous, like the lobus centralis of other animals, with the lamina perforata antica; but in view of the fact that it is not overhung by the operculum, but continuous with the præcentral and post-central gyri, it is to be doubted whether we have here the true lobus centralis to deal with. I have usually been able, where other criteria failed, to utilize the extent of the claustrum as a gauge for the proper extent of the insula, but in the instance of the seal, circumstances adverted to prevented this. It is certainly suggestive that while the seal, with its greater general intelligence, should possess a cerebrum much more intricately convoluted than the bear or even the anthropoid apes, the latter animals should far exceed it in the development of the island. The localization of the more delicate motor innervations of the tongue and facial muscles gains some support from the fact that the seal's facial muscles are rudimentary and the tongue movements limited, while the facial movements of the monkey tribe are various and complex. In the bear also the tongue is an important organ of prehension, and can be employed outside of the mouth with greater skill than the paws. I presume that the otter, which in its anatomical structure exhibits a transition from the land to the water carnivora, will show peculiarities of its cerebral structure calculated to elucidate that of the seal.

In monkeys we find every transition, from the smooth and limited island of the smaller species to the extensive and richly convoluted island of man.   As we rise from the lower to the higher, we observe that while this area is triangular in all, that the altitude of the anterior vertical side of the triangle shows the chief increase ; so that while this region is a very acute triangle with its sharper apex directed backwards in lower monkeys, it has almost become isosceles in man.   The horizontal diameter shows the least increase.   In the cercopithecus, cebus, lagothrix, macacus, and ateles, the lobus centralis is smooth and differs merely in size ; in the inferiorly organized platyrrhine monkeys, the anterior inferior border is frequently uncovered.

In the baboon we already perceive a distinct sulcus, which, like that of the bear, runs antero-posteriorly ; in addition there is a faint indication of another one, parallel to and above it, corresponding to the middle height of the overlapping operculum.   The orang-outang shows two clear sulci running as from a common inferior starting-point and separating above, thus indicating the course of the sulci in man.   The orang-outang's island contains, therefore, three gyri.   In the chimpanzee the lobus centralis is like that of the orang, completely covered by the operculum, the (third) inferior frontal gyrus and the temporal lobe, the same relation as that obtaining in man.   It is more extensive in the chimpanzee than in the other anthropoid, and bears the same relative proportion to the entire cerebral dimensions as in the human being.   It possesses four distinct gyri, the last two branching from a common root. In one chimpanzee, whose brain was atypically asymmetrical, I found indications of a fifth gyrus posteriorly, but this is probably an exceptional occurrence, and as I have no record of the condition of the atrophic hemisphere, has no special value.

From the fact that not only the anthropoid apes, but even some Old World monkeys and even the bear, possess gyri on the island, it follows that the categorical dictum, " only man possesses gyri on the island of Reil," must, like Richard Owen's claim that " man alone possessed a posterior cornu, and hippocamp," or that " in man alone the cerebrum overlaps the cerebellum," be relegated to the errors of the past.

In the chimpanzee the gyri of the lobus centralis run rather upwards than backwards, and show, as stated, a tendency to bifurcation, thus increasing the resemblance to the human island.

The latter, however, is far more complex than that of the highest anthropoid (under normal circumstances); it contains not only more gyri, but these are separated by deeper sulci than those in the troglodyte. The usual condition is that from four to six gyri run from the lower angle upwards and bifurcate at the upper half of the island. The more posterior the gyrus the more oblique is its course and the greater the tendency to bifurcation, so that on the subdivisions of the last gyrus a ternary subdivision is occasionally noticed. Since the inner aspect of the operculum is provided with gyri, which constitute an exact negative of the insular gyri, dovetailing with them by immediate contact, it follows that the more highly developed the island, the more highly developed will be the internal face of the operculum. In imbeciles I have frequently found merely five undivided gyri, and in one instance a disposition exactly imitating that of the chimpanzee. All these individuals were possessed of articulate speech, though, corresponding to their general condition, only to a limited extent. In terminal and secondary diminution of the intellect, accompanied by corresponding loss of word-imagery, nothing aberrant could be discovered in the disposition of the gyri; this might of course have been anticipated. But in one instance of congenital imbecility with almost total absence of the faculty of language, the gyri were numerous and well developed, as were all the other convolutions. The brain of this patient, whom I have designated as a macrocephalic idiot, weighed sixty-eight ounces, and is with one possible exception the heaviest human brain on record. It is to be noticed, however, that the neuroglia was hypertrophied, the ependyma layer of the cortex thickened and the peduncular tracts disproportionately small.*

I will not hesitate to predict, judging by analogous cases,

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*The weighing of this brain was not undertaken with that care which could enable me to vouch for the exact accuracy of the figure given. I have them at second hand.

that in such an idiot as the well-known John Rouse, of Randall's Island, the island of Reil is far behind that of an anthropoid ape, but yet this remarkable monstrosity has learnt a few words, which he uses with a certain purpose, although in every other respect he seems to be inferior to our ordinary domesticated animals.

In certain idiots, not only has the lobus centralis been found defective, but even uncovered by the parts usually bordering the Sylvian fissure.

And these facts do not disprove the localization of the speech innervations in the island and operculum, but they show that this region may be comparatively well developed and speech be absent (troglodyte), whereas, on the other hand, the partial possession of the speech faculty may be associated with a far more defective island (in case of certain idiots). This shows that other factors must co-operate with the insula in this faculty, and that these lie in the association tracts extending from the island to distant cortical parts ; and that these tracts have been ground out in countless generations of beings whose ancestors acquired the faculty *gradatim,* are inferences in perfect accordance with the prevalent physio-psychological and anthropological views.

It explains how a relatively defective brain may stand higher as regards one special function, than a generally better developed one.

We are struck with one fact, in examining the relative development of the island of Reil in this series of animals, that if the surface area of the lobus centralis were to be arranged in a continuous series, beginning with the smaller South American monkey and terminating with man, and the area of the whole cortical expanse be arranged in a parallel manner, we should find that both series presented a remarkably similar increase. With this another observation is in accord, that where two closely related species are of different bodily size, the larger one has the more convoluted island of Reil. We see from this that the insula merely follows the general cortical development in the simian series.

A very peculiar condition is manifested by the pachyderms and ungulates: the larger species possess a distinct lobus cen-

tralis which borders, at the base of the brain, on the immense white olfactory convolution. The connection of the lobus with the basilar grey matter of the third ventricle is consequently obscured. How much of the area proper of the island is also thus obscured in some species, I am unable to determine; at all events, whatever be considered insula of such grey matter, possesses an inferior structure.

A most remarkable contrast is exhibited in regard to this lobe, by the hippopotamus and the horse. The former has a smaller cerebrum, possessing the simplest gyri, than the horse, the gyri of whose brain are as numerous and whose sulci are in places as deep as those of man! Yet the insula is small, simple and difficult of identification in the horse, extensive, prominent, and richly convoluted in the hippopotamus! We here have a repetition of the discrepancy existing between the bear and the seal, only much more intensified. In both instances the better developed brain has the worst developed insula. So that parallelism between the general cortical, and the special insular development does not hold good here, as it did in the simian and anthropoid series.

In the instance of the bear compared with the seal, I looked upon the bear's island as the normal carnivorous type, from which the seal's island was a retrogression; in the case of the two pachyderms, I consider the horse's as representing a normal type of this group, whereas the hippopotamus' manifests a hyper-development. Now the seal's atrophy found a hypothetical explanation in the atrophy of its facial and the disuse of the glossal periphery, but how can we even hypothetically explain the insular hypertrophy of the hippopotamus? The innervation of its tongue is certainly not required to be of a delicate character, nor are its facial muscles, excepting those of the nostrils, well developed. The mass of the tongue muscles and of those of mastication is immense, it is true, but this is equally the case with the muscles of the neck and the remainder of the body. For the present the lobus centralis of the unwieldy and Bœotian denizen of the Senegal, exceeding the human in its antero-posterior diameter, though only half its altitude vertically, and richly convoluted by festooned gyri in four pairs, is an enigma to the physiological anatomist.

Its upper half measured vertically is covered by the over-hanging free margin of the convexity, the posterior fifth measured horizontally is covered by the mastoid lobule.* Although its gyri, on first sight, appear to run in a direction analogous to that of the other species considered in this paper, yet from their frequent alternate junctions with their fellows at the upper and lower extremities, it would seem that the influences which had determined the undulating antero-posterior course of the convolutions of the general convexity, had also had some influence on the lobus centralis, contrary to the general rule.

While the series of animals examined by the writer is far from being as complete as he could desire, yet a few conclusions can be drawn from their examination as given above.

Firstly, that the degree of development of the insula is not an indicative of the general intellectual standing of a species.

Secondly, that the innervations of the tongue and lips, which can be presumably referred to this area, or its histologically similar neighborhood in carnivores and simians, cannot be so referred in all other animal groups.

Thirdly, that even where the insula and its contiguous areas can be shown to have a relation to the function of speech, teratological deficiencies reducing it as in idiots to inferiority as compared with speechless anthropoid apes, do not incapacitate from this function. It is an open question whether the coincident defects of the cerebral organs in general in idiots may not be as important, if not more important factors in such amnesic aphasia as is present. Finally, it follows that only one element of the speech function is located in the lobus centralis and near it, that is the mechanical; the lobus is not the ruler but the mediator of this function.

PART VI.

The Olivary body in Man, the Anthropoids and lower Mammals.†

As we trace up the anterior cornu of the spinal cord into the medulla oblongata, through a series of successive trans-

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* The analogue of the human temporal lobe.
† Read before the American Neurological Association at its annual meeting, 1878.

verse sections, we find that the reticular breaking up which began at the lateral cornu of Clark, now involves the anterior cornu also.   This is preparatory to the disappearance of the grey matter of the anterior cornu, as a distinct mass.

To this breaking up there are two exceptions : the inner aspect of the anterior cornu, and that portion which corresponds to the anterior root zones, retain their masses in a concentrated form.   In the altitude of the inferior pyramidal decussation the two masses are separated, higher up they join at an angle, and in the altitude of the uppermost hypoglossal nerve roots, they again separate ; from this point upwards, the innermost body begins to disappear.   The inner body is composed of the spongy variety of grey basis substance, and contains multipolar nerve cells of the larger kind.   The lower body is composed of gelatinous basis substance, and contains smaller, round nerve cells, with few and attenuated processes.

Henle* has confounded the two under the common title of a nucleus pyramidalis, after Stilling.   But since they originate separately, since their subsequent junction is accidental, and their histological structure radically different, they must be considered as two distinct bodies.   The lower one has the same structure as the *nucleus dentatus olivæ*, and in certain levels is continuous with it as will be shown ; the name proposed by Lenhossek, *internal accessory olivary nucleus*, ought, therefore, to be retained for it.   The other division, the one containing the large multipolar cells, might retain the title of nucleus pyramidalis, if this did not lead to the erroneous conception that it was situated in the anterior pyramids, from which it is quite remote ; as it lies in the inner division of the reticular formation, I propose to term it nucleus internus of the formatio reticularis.   It has no relation to the olivary nuclei beyond the accidental and slight junction alluded to.

The internal accessory olive is the only representative of the olivary nuclei in the lowest mammals and in birds ; it attains a high development in the parrot.   It is also the first portion developed in the embryos of higher mammals, and since the proper dentated nucleus is developed from it, as will be shown,

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*Henle, *Handbuch der systematischen Anatomie des Menschen*, Vol. III., Part 2, p. 192.   Figures 124, 127, 129, 132.

it is to be regarded as the fundamental olivary nucleus, although it is in simians and in man far outstripped in development by its derivative, the nucleus dentatus.   Duval[*] states that in the cat, rabbit and other lower animals, the whole so-called olivary nucleus was homologous with the internal accessory nucleus alone, and that in these animals the external accessory olive and dentated nuclei were absent.   Such a statement could be founded only on the most superficial study, and an imperfect series of specimens.   All three bodies are present, side by side, in the cat, lion, bear, seal and dog ; there is not the slightest difficulty in tracing the different divisions of the olive through this series.   In all, the inner accessory olive is continuous at some point with the dentated nucleus, which is dentated, however, only in man and the simians ; in others it is a simple U-shaped lamina.

In the seal the inner division of this U lies horizontally, and, therefore, in a straight line with the equally horizontal inner accessory olive ; their continuity is interrupted here and there by the hypoglossal nerve radicles.   In the bear this division of U-shaped nucleus stands vertically, and is parallel to the internal division, and the two are continuous at their highest points.   In a South American monkey (Cebus apella) the lowest and innermost dentation of the main nucleus lies in a direct line with the inner body ; in the baboon the latter is not a flat lamina, but a thick, roundish body, with which the inner lip of the dentated nucleus is connected as in the bear.   The chimpanzee shows relations which place it far nearer the human being than to the monkeys next below it in the scale. The internal accessory nucleus here occupies a position exactly like that of man, running along the outer aspect of the pyramidal bundle.   At its upper end a thin lamina runs out and downward at an acute angle, and thus continues the substance of the inner with the dentated nucleus.   This same relation obtains in man, more distinctly in certain individuals than in others, and more clearly in sections through the middle part of the olive than through those striking either extremity.   The continuity is interrupted here and there by the fibræ arcuatæ

going from the raphe to the restiform column. Figure 129 in Henle exhibits this condition.

Since the inner accessory olive is present before the dentated nucleus becomes visible in lower sections, and disappears before the latter in higher ones, it follows that only the upper half of this body is connected with the dentated nucleus.

In like manner is the external accessory olive continuous with the upper dentations of the simian and human olive, or the upper and outer half of the U-shaped olive of the bear, lion and seal. I can, therefore, consider Meynert's representation of the two accessory olives as the everted edges of the hilus of the dentated nucleus, as eminently proper and apt. It is noteworthy, that while the development of the dentated nucleus keeps pace with the general cerebral and cerebellar development, it does not reach a higher stage in the seal as compared with the bear. Schroeder Van der Kolk made an unsuccessful attempt to bring the olivary nucleus in relation to the hypoglossal nerves, as co-ordinator of the tongue, and, doubtless, the coincident deficiency of the hypoglossal nuclei and nerve roots and the relative deficiency of the olive might be utilized in a renewed examination of this theory. It is possible however that some peculiarities of the cerebellar organization, or of the restiform columns, of which the olive is an internuncial station, according to Deiters and Meynert, may lie at the basis.

The hypoglossal nerve radicles pass through the olivary body differently in different individuals and in different parts of the same medulla. They have no other relation to these bodies, and if the olivary nuclei possess any connection with the tongue, it is not with the nerve roots, but the nuclei of that organ's muscles, through fibræ arcuatæ, such a connection cannot be anatomically traced.

The Cebus has a single indentation of its olive ; the Lagothrix (a larger but related genus) has two ; the baboon has four indentations, and these separate four and five denticulations ; the anthropoid chimpanzee has fifteen, most of which are, as in man, the result of a secondary subdivision of larger folds. The largest fold is the one bordering the lateral field of the oblongata nearest the vago-accessory nerve root exits. The

same fold which can be identified in man, is also the largest in the latter's case. The human olive gains additional complexity by the increase of the secondary subdivisions of larger folds. I find a series of human olives to possess, respectively, once seventeen, twice eighteen, once eighteen with an additional four upon an internal scroll-like reduplication, three times twenty-one, and once twenty-three folds, or an average of twenty. The substance of the olivary grey matter is relatively thicker in man than in the ape, but if we take into consideration the proportionate progress, shown in the series, Cebus (two), Lagothrix (three), Cynocephalus (four), chimpanzee (fifteen) and man (twenty gyri), we shall come to the conclusion that in respect to the olive as with regard to the lobus centralis, and the general convexity, the chasm between man and the anthropoid is far less than between the latter and the common Old World simians.

There are many and curious individual variations in the olivary body of man. In some cases the connecting bar with the inner accessory olive is as distinct as in lower animals; occasionally an inner scroll-like appendix is noticed, especially in richly developed brains. The most constant feature in imbecile and idiotic brains, is the compression of the outer and upper half of the olive, which is rounder and fuller in well developed human brains and flat in the chimpanzee. The outer larger fold referred to, is in such cases the one which suffers the chief reduction as to secondary folds.

In cases of pathological or teratological asymmetry of the cerebellum, I have found the olives, when asymmetrical also, which was not always the case, to follow the opposite *cerebellar* hemisphere; if the right hemisphere was atrophic, the left olive was the smaller, and vice versa. This is confirmatory of Deiters' and Meynert's statement that the olive stands in connection with the opposite cerebellar hemisphere, through the restiform decussation; on anatomical grounds alone this connection would be hypothetical.

In passing I would state, that the olivary nuclei of pachyderms present us with types quite aberrant from that just considered : that of the hippopotamus is quite bizarre in this direction, and Duval's statement may apply to these animals

but I am not prepared to endorse it unreservedly, either in their case or in all the rodentia.

The external prominence of the olivary body is caused by the pressing outward of arciform fibres, through their displacement by the olivary nucleus, as has been shown by Meynert. This prominence is not always an indication of the development of the nucleus, since it is larger in the seal than in the bear, and even in individuals of our species I have found a flat eminence, due to overlapping of the anterior pyramids, to conceal a better developed olivary nucleus than another one which stood out in high relief. Few human brains can show as clearly demarcated and elevated an olivary eminence as that of one chimpanzee in my possession. In the chimpanzee whose number of olivary indentations was given, it was as prominent as in a child of the same age (two years).

The eminence is very distinct in the baboon, bear and seal, and although much narrower in the feline and canine carnivores, is yet unmistakably present, although Meynert* denies this. Doubtless his specimens had been permitted to rest on their basal face too long, obliterating their demarcating depressions.

I have not specified in this paper that my description deals only with that olive which is termed "inferior" by writers, in contradistinction to a body in the trapezium described as the "superior olive." I think that the necessity of making special mention of the topography of these bodies can be obviated, by terming the lower body the olive *par excellence*, and the upper, the "nucleus of *the trapezium*," especially as the so-called superior olive of Luys is an entirely different body from that described by Meynert, Henle, Dean, Clarke and others under that title.

PART VII.

The homology of the corpora quadrigemina, and some observations on the posterior longitudinal fasciculus.

Since the comparative development of the nervous system has occupied the attention of anatomists, it has been regarded as a fundamental difference between the mammalia and sau-

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* " Die Gehirnbau der Saugethiere." *Stricker's Handbuch der Gewebelehre*, II.

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ropsida, that only the former possessed corpora quadrigemina, their place in the latter being occupied by bigeminate optic lobes. Neither proposition, although adopted in zoological classification, is accurately correct.

The first steps toward correcting this mis-statement, were made when it was shown that only the anterior pair of the corpora quadrigemina were connected with the optic tracts. Since the entire optic lobes of those reptiles possessing only a single pair are connected with these tracts, it follows that, physiologically, at least, only the anterior pair of mammals is represented in the optic lobes of birds and reptiles. Forel makes this deduction, and suggests that in the singular mono-treme ornithorynchus, a transition between the mammalian and reptilian form of the optic lobes may be found. I am able to present a different solution of the problem.

In examining the brains of two large snakes of the anaconda family, I found distinct corpora quadrigemina. The posterior pair is as clearly demarcated from the anterior by a transverse sulcus, as the members of the anterior and posterior pairs are separated from each other by the longitudinal sulcus. The posterior pair is distinctly tuberculate, and measures about one-third the dimensions of the anterior.

In a series of transverse sections made through one of these brains, I find that as in mammals, the optic tract enters only the anterior pair.

A single instance like this, destroys the validity of the characterization of the sauropsida as a class possessing only two lobes in the mesencephalon, and I made a renewed examination of the conditions obtaining in other reptiles. In several families, but notably well developed in the turtles, I succeeded in discovering the homologue of the posterior pair, as a concealed ganglionic mass, lens-shaped, and containing the same elements as the posterior pair of the anaconda. It is concealed under an arciform fibre-mass continuous with the cerebellar medullary lamina, and lies directly behind the optic lobes properly so called. It has no connection with the optic tract, and appears to be in relation with the sensory root of the fifth pair.

From this it follows, that reptiles as well as mammals

possess the homologue of the posterior pair of the corpora
quadrigemina; that while in most reptiles this homologue is
separated from the anterior pair, and concealed under other
structures, it arises to the same topographical level in the
python family as in mammals, and finally that the posterior
pair and its homologues are in no respect ganglia of the optic
nerves.   I can, therefore, fully assent to Forel's statement that
the two pairs of the corpora quadrigemina are neither sub-
divisions of one common ganglion, nor even analogous ganglia,
such as Meynert would make them.

As a rule in the animal range, it seems that the higher a
zoological family, the more distinctly do the posterior tubercles
become demarcated and developed.   The minimum is in the
anaconda, and from this point, of the animals examined, the
opossum, rabbit, dog and man, represent an ascending series.
These bodies are very small in the opossum.   In comparing
the relative development of the anterior and posterior tubercles,
those animals only should be placed in the series which have
well developed eyes, for a defective visual apparatus, associated
as it always is with rudimentary anterior tubercles, leads to an
apparent but deceptive absolute preponderance of the posterior
pair, which in reality is only apparent, as in the bat and
mole.

In view of the entirely distinct character of the anterior pair
of the corpora quadrigemina from their posterior pair, it
would be desirable to re-examine the embryonic development
of these bodies.   His, in his lectures (1874), stated that the
single mesencephalon was first divided into two lateral halves
by a longitudinal sulcus, which was subsequently crossed by a
transverse sulcus, dividing it into four divisions.   I doubt
whether this statement was based on a sufficiently extensive
series of observations made on mammals.

In reptiles the optic lobes exhibit a true cortical structure,
and the cortical lamina is covered on both sides by white sub-
stance.   The outer consists of fibres entering the optic tracts,
the inner of projection fibres of the second category, which run
parallel with the contour of the Sylvian aqueduct, and in part
decussate beneath its floor.

This is the homologue of Forel's fountain-like tegmental

decussation.* The innermost fibres of this mass pass into the oculo-motor nucleus of the same and of the opposite side, still others which fail to decussate, leave their original direction and become longitudinal, constituting the posterior longitudinal fasciculus.

This fasciculus, thus shown to originate in the deep white substance of the optic lobes, probably has the same origin in mammals, since in no animal can it be traced beyond the posterior commissure. Forel has already supposed such an origin for it. I am very much inclined to doubt whether any statements that this fasciculus originates as Meynert, Huguenin and Rohon† claim, in the cerebrum, or the sublenticular grey masses, are based on the comparison of a sufficient number of sections.

Flechsig and Forel consider this fasciculus as a connecting bond of the oculo-motor nuclei and the spinal grey substance. It can certainly be traced with great clearness into the column of Tuerck, especially in lower animals. In a series of longitudinal sections of the cat's brain, I find that it sends a distinct branch into the trochlearis nucleus, in which it becomes lost. The abducens nucleus is entered by a similar bundle, whose connection with the longitudinal fasciculus cannot be traced ; it certainly does not come from the raphe, and I consider it derivable from the former by exclusion.

* Forel, "Untersuchung ueber die Haubenregion und ihre oberen Verknupfungen, etc." *Archiv fuer Psychiatrie*, VII.

† Rohon, "Das Central Organ des Nervensystems der Selachier." *Denkschriften d. Kais. Acad. der Wiss.*, 1877.

(*To be continued.*)